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APPLYING COMPUTERS
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to
INDIVIDUALLY PRESCRIBED INSTRUCTION

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by

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and

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APPLYING COMPUTERS
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Research for Better Schools, Inc. has as its major mission, the individualization and humanization of learning. One program of the corporation - Individualizing Learning Program - is concerned with the field development and dissemination of Individually Prescribed Instruction, Automated Learning Management System, and Computer Assisted Instruction. This paper will attempt to describe all three program components.

Individually Prescribed Instruction

Individually Prescribed Instruction (IPI) is an instructional system based on a specific set of educational objectives, and has correlated to these objectives diagnostic instruments, teaching materials, and methods.

Since IPI curriculum is based on a carefully sequenced and detailed specification of educational objectives, these objectives are used in planning most other aspects of the instructional system. Lesson materials, teaching methods, instructional settings, diagnostic tests, as well as the monitoring systems are geared to the instructional objectives, thereby permitting pupils to proceed quite independently.

A basic aspect of IPI is a rather detailed provision for diagnosis of pupil skills and abilities and continuous monitoring of pupil progress. Detailed diagnosis is made of the initial state of a learner coming into

a particular instructional situation. Four types of assessment instruments are used in IPI. They include a placement instrument, used in locating students on the learning continuum; Pre-Test of each unit of work used to measure the specific objectives within a unit; Post-Test of each unit to determine mastery; and Curriculum-Embedded Tests measuring progress toward an objective.

A unique feature of IPI is its requirement that each pupil's work be guided by a written Prescription prepared to meet his individual needs and interests. The Prescription is an important two-way communication link between the student and the teacher. The teacher communicates to the student the choices made in different materials and different settings to achieve an objective. Information about student progress is communicated to the teacher through the Prescription. For the initial Prescription the teacher will generally consider the following factors: (1) the ability level of the child, (2) the general maturity of the child, (3) the type of learner, and (4) the student's reaction in various instructional settings.

The student generally begins work independently on the prescribed materials. Most of the students can proceed through the prescribed materials with a minimum of teacher direction and instruction. When assistance requiring extended explanations or instruction is required, the teacher gives such assistance. In order to free the teacher for instructional decision-making, tutoring, and evaluation of student progress, the scoring of materials, tests and the tabulation of the student data is done by teacher aides or in some cases by the children themselves.

Inherent in the design of the IPI system is its capability for improvement. An essential aspect of individualized instruction is the provision for charting the progress of each student as he moves through the curriculum and the availability of these reports for teacher use. This

information is necessary for individual prescriptions and classroom organization. The data to be used for prescription writing should include: (1) general ability level in the given subject, (2) the degree of mastery or lack of mastery in each skill in the particular unit assigned to the student, (3) information related to the child's progress in previous units directly related to the skills in the present unit, (4) detailed information related to the pupil's progress as he moves through the various tasks related to the particular skill or objective assigned, and (5) general learning characteristics of the pupil as they relate to the assigned task.

Information needed by the teacher for day-to-day classroom organization must include: (1) level, unit and skill of each pupil in the class, (2) the approximate length of time (days) the student has been working on a given skill, and (3) the next immediate skill for each pupil in the class. With this information the teachers can organize the classes for small and large group instruction, peer group discussions or individualized tutoring. The availability, accuracy, and the format of these reports is the key ingredient to the success of IPI.

Furthermore, these data are used for continual evaluation and strengthening of the curriculum and instructional procedures, permitting the developers to constantly improve the system.

The model, as developed, considers the following aspects of instruction as they relate to the individual: (1) detailed specification of educational objectives, (2) organization of methods and materials to attain these objectives, including a variety of paths for attainment of mastery of any given objective, (3) a procedure and process for the diagnosis of student achievement in terms of the educational objectives, (4) individual daily evaluation and guidance of each pupil including a system for individually prescribing the learning task that the student is ready to undertake, (5) provision for frequent monitoring of student performance in order to

inform both the pupil and the teacher of progress toward an objective, and (6) continual evaluation and strengthening of curriculum and instructional procedures.

The Learning Research and Development Center at the University of Pittsburgh is the creator of Individually Prescribed Instruction and specializes in the research and basic design of new educational technology.

Individually Prescribed Instruction was developed by Drs. Glaser, Bolvin and Lindvall with the cooperation of the University of Pittsburgh and the Baldwin-Whitehall Public Schools of suburban Pittsburgh, Dr. W. R. Paynter, Superintendent of Schools.

During the school year of 1963-64, the Learning Research and Development Center and the Baldwin-Whitehall Public Schools initiated an experimental project to investigate the feasibility of a system of individualized instruction in an entire K-6 school. This came about as a result of a series of prior exploratory studies, begun in 1961-62, designed to test preliminary notions on a smaller scale in single classrooms. The work started with the use of programmed instruction in an intact classroom. "Intact classroom" being defined as a classroom unit in which the teaching practices were oriented around the conventional grade-by-grade progression of learning.

As work proceeded, it soon became apparent that the significant individualization feature of programmed instruction could not be manifested unless the intact classroom changed its organization to permit a more flexible progression.

As a result, a second set of studies was instituted, using programmed instruction and other materials in a more flexible context. Out of this experience grew the Individually Prescribed Instruction project currently in progress, in which various combinations of instructional materials -- including programmed materials, special workbook and test procedures -- and teacher practices are being used for the purpose of adapting them

to individual student requirements.

Research for Better Schools, a Title IV Regional Educational Laboratory, has the major responsibility for the field development, field testing, and dissemination of Individually Prescribed Instruction. Included in this responsibility is the study of problems encountered in a variety of institutional settings. It also includes the investigation of the strategies that are necessary for widespread dissemination of IPI. This activity is of major proportion, since the task of implementing this type of instruction in a variety of ongoing school programs is quite different from that of implementing IPI in the Oakleaf School.

Automated Learning Management Systems (ALMS)

Research for Better Schools, Inc., in cooperation with the Westinghouse Learning Corporation and the Quakertown Community School District in Bucks County, Pennsylvania have been developing an Automated Learning Management System (ALMS) for Individually Prescribed Instruction (IPI) in elementary mathematics. Unlike computer assisted (or based) instruction, the technology is currently available to handle what some researchers-developers refer to as computer managed instruction -- RBS prefers the acronym ALMS because the implications for individualizing instruction go far beyond much of the current writing in computer managed instruction.

The initial objective of ALMS is to provide classroom management information for the teacher on the individual learning procedures for the individual student.

Two broad areas of concern at the base of developing such a system are: How do teachers make learning prescriptions for youngsters? How do teachers diagnose the learning difficulties youngsters may be having? Hopefully, teachers will begin to ask pertinent questions about youngsters and researchers will develop the necessary information files for the teacher.

In undertaking the design of such a system, it is not possible to fully predict the form or content of optimally useful input data from students and their environment (including the teacher), the appropriate procedures for processing that data, and the mode of presentation of the resultant information for educational purposes. However, the inputs, processing routines, and outputs include the following:

1. Collect, analyze and feed back to teachers and students, individualized student performance data.
2. Integrate student performance data with the sub-system of student permanent records.
3. Develop and test a new format and processing system for student permanent records.
4. Collect, analyze and feed back to teachers data pertaining to their prescription patterns.
5. Correlate student achievement with instructional material segments for purposes of evaluation.
6. Collect and analyze information related to student learning styles.
7. Develop and test scheduling sub-systems to support the work of the teacher.
8. Collect, analyze and feed back data about each student on a continuing basis by skill mastery per level unit.
9. Develop feedback mechanism to teachers for appropriate student test and mastery data.
10. Create and maintain a student data file for profiles, pre- and post-tests, and curriculum embedded tests.
11. Develop statistical summaries and normative data by school, teacher and student.
12. Develop and test a data base and procedures for computer generated prescriptions.

13. Develop and test a data base and procedures for use by teachers in improving their guidance and counseling practices.

Data is collected for each student at three specific points as he progresses along the IPI continuum. The first is at registration and placement where his files are initialized and his original unit assignment is generated. The second is at pre- and post-test time when he is either passed on to a new unit or cycled into a particular skill for work. The third data input point is at skill mastery when the student's CET scores and completed skill prescription are recorded. Another type of system demand will be requests to inquire from the system such things as student status reports and other inquiries when desired. Card requirements are:

1. Prescription cards
2. Curriculum Embedded Test cards
3. Pre- / Post-Test cards
4. Inquiry cards

Initially several experimental forms of reporting are being generated. An outline of the basic planned report include:

1. Immediate messages
    a. Placement message
    b. Skill mastery message
    c. Pre-Test entry message
    d. Post-Test entry message
2. Immediate reports
    a. Current student skill information
3. Overnight reports (automatic upon data entry)
    a. Placement Profile
    b. Skill mastery
    c. Pre-Test analysis
    d. Post-Test analysis - unit summary

4. Overnight reports (on request)
   a. Student progress between two dates
   b. Student unit progress to date
   c. Skill information report
   d. Current grade listing by student
   e. Current class listing by student
   f. Grade (or teacher) status report
5. Periodic reports (less frequent intervals)
   a. School status report
   b. Quarterly student progress report
   c. Yearly summary
      (1) Unit and skill data
      (2) Teacher, grade, and school data
      (3) Test data (pre and post).

Computer Assisted Instruction (CAI)

Since October of 1967, Research for Better Schools, Inc. and the Division of Instructional Systems of the Philadelphia School District have been cooperating to adapt Individually Prescribed Instruction (IPI) mathematics materials to Computer Assisted Instruction (CAI).

RBS attempts to keep and up-to-date information based on some of the leading technological advances. Such information, when processed properly, allows the corporation to make wise investments. The following description traces the how and why of the RBS - CAI activities.

Working with computers can be an expensive business. To date, the total budget of the Division of Educational Laboratories in the Bureau of Research (Office of Education) has not been sufficient to support a major CAI project. The hardware costs and the human resources make such a major investment unlikely over the next several years.

RBS, dedicated to individualizing learning, sees the need and use of the computer as an actual aid in extending individualized instruction as well as ultimately replacing certain teaching functions. How to invest a minimum amount of money wisely and still obtain high results in both experience and actual instruction for students becomes a real challenge.

Fortunately for RBS the Philadelphia School District made a major commitment to computer assisted instruction. As a direct result of Title I (ESEA) funds 1965 - 1966, Philadelphia invested approximately $1.2 million in a system designed and installed by the Communications and Electronics Division of the Philco-Ford Corporation.

Already a leader in teaching youngsters about the place of computers in a technological society, Philadelphia suddenly made a quantum leap into CAI.

The advantages for RBS were just too good to pass by. Here, in our own backyard, was a major city with the type of hardware allowing for experimentation without RBS having to make any investment in hardware rental or purchase.

During the school year 1967-1968, the Philco-Ford equipment was ready for use. RBS entered into a joint agreement with the Philadelphia Board of Education during this school year to undertake the development of the IPI mathematics program. The mutual benefits to both parties are many:

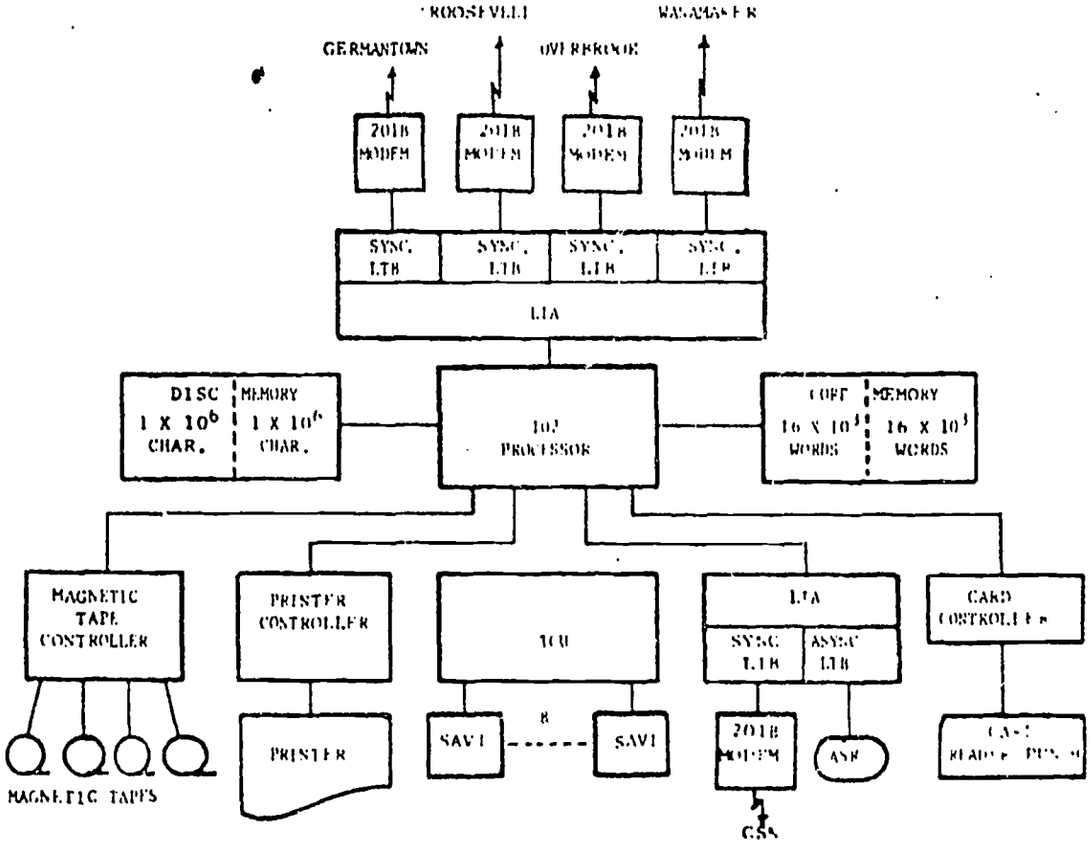
- Basically, RBS pays for the writing and computer team. To date, this has cost the corporation $208,000 over two school years.
- The school board provides all equipment, office space, and furniture.
- RBS enjoys the use of forty terminals, eight in each of five school locations.
- As a result of these site locations, RBS also enjoys the advantages of working with populations from all age spans including adults. The main driving computer is located in an old converted factory which houses the major innovations taking place in the Philadelphia School District.

- The system hardware actually contains most of the combined features of the existing rationale described earlier including micro-mini equipment, television (CRT) display for open and closed circuit, and a computer configuration with the magnitude of an IBM 360/50. Here then was a convergence of the best of all worlds.

The central facility uses a Philco-Ford 102 processor with two million characters of fixed head disc and 32K words of magnetic core memory. In addition, the central facility includes four tape transports, a line printer, a teletype, a card reader, a card punch, interfaces for the four dedicated data lines connecting to the four remote clusters, and eight graphical CRT terminals as shown in Figure 1. The central facility is located in a "Computer Center" housed in the Intensive Learning Center.

Figure 1

SYSTEM CONFIGURATION



A Philco-Ford 102 processor is located in each of the four remote schools and is used to drive eight SAVI (Student Audio-Visual Interface) terminals. The 102 processor in the cluster accepts information from the central 102 computer over leased 2400 baud data lines, stores the information on a one million character disc, and later retrieves the information for use with the individual student terminals. Two classes of responses are received from the student terminals, keyboard, and light pen. The terminal is a 12-inch television screen adapted for computer operation. All displays in the processor-generated mode are composed from 240 scan lines having 320 active program-controlled dots per line.

Each cluster automatically receives from central the necessary digital information to serve its users. The schedule of users for a given day is established earlier so that material may be prepared by central. The central facility maintains a library of curriculum schedules, enrollments, and computer programs for transmission to the clusters as requested. All lessons and student files are stored on magnetic tape at the central location.

The language used to develop the curriculum material is called Inform. The curriculum is written on preprinted data forms that specify the displays, questions, response data, and the procedural flow of the data. An author is provided flexibility in specifying screen effects. He may replace, add to, overlay, or erase lines or individual characters on the screen. Authors indicate the size and position of the response areas through the use of keyboard and light pen control characters. Keyboard responses may run to 100 alphanumeric characters in length; light pen responses may occupy designated, lighted areas on the screen.

Where RBS is and where it intends to go will depend in large measure on the successes and failures of our work in placing the IPI math program on the SAVI system. Internal papers, reports, and a written agreement keep the Board of Education and RBS in a constant state of evaluation.

Projections are cautious and subject to change, dependent upon evaluations. Presently, the IPI math is viewed as a diagnostic instrument. The computer makes possible actual instruction and the storage of information on student performance. Some materials will be developed on line, some off line, depending upon the cost factors. Drill and practice, for example, can be done off line at a much lower cost.

All modes of instruction are being considered including problem solving, simulation, gaming, drill and practice, tutorial instruction, and diagnostic prognosis and instruction.

Approaching the problem of cost feasibility presents a challenge because of the unknowns. The Philco-Ford SAVI system is, for all practical purposes, a prototype system and has not been calculated on a mass production major sale base. Another problem is the question of how teachers are to be employed in the system of CAI. Even given the unknowns, certain factors can be accounted for which demonstrate a feasibility that could indeed be major prior to 1978-1980.

First, the RBS costs are quite modest. For fiscal 1970 the corporation will need to invest approximately $150,000. This investment will yield a return as follows:

- a continuation of the developmental effort in author writing and programming
- research conducted in selected areas
- evaluation as a continuing cycle
- testing on a variety of populations.

SUMMARY

Individually Prescribed Instruction (IPI) is a major break from the traditional classroom setting. A completely new instructional role for the teacher has been structured. All too often in the past the teacher has served as the final authority and as a dispenser of information to students. In contrast, IPI is organized so that the teacher becomes a manager of a system for instruction, a diagnoser of learning problems, and a prescriber of instructional materials and setting.

Perhaps an over exaggerated definition of IPI would be to state that it is the utilization of humans to simulate in a manual paper mode that which can be accomplished by the computer and the best of our automated technology.

Little doubt remains in the minds of those who have invented and experimented with IPI that we are talking about an evolutionary approach in education, an approach which ultimately will take full advantage of research and development techniques as well as the emerging technologies.

The best published operating description of IPI was contained in the 1966 Yearbook of the National Society for the Study of Education, Part 2 -- as written by two of its inventors, John Bolvin and Maury Lindvall from the Learning Research and Development Center at the University of Pittsburgh. The following remarks are abstracted from the operating principles developed by the above authors.

Individually Prescribed Instruction is an example of the application of the principles of programmed instruction to curriculum development in the elementary schools. This leads to certain basic assumptions underlying the IPI theory.

1) IPI is the idea that learning is something that is ultimately personal and individual -- learning takes place only on an individual basis.

2) Curriculum sequences must be developed in such a way that they represent a long term development process which ignores guidelines.

3) If pupils are progressing individually, questions about grouping, classification, or housing are irrelevant.

Research for Better Schools, Inc., in cooperation with the Westinghouse Learning Corporation and the Quakertown Community School District in Bucks County, have been developing an Automated Learning Measurement System (ALMS) for Individually Prescribed Instruction in elementary mathematics.

The learning prescription has been converted to punch cards, which permits a quick translation of the progress each student is making into central storage. Teachers are provided, immediately after each class, pertinent information about student growth and progress in the math systems. The data is used by teachers in making decisions concerning the proper instructional materials and instructional settings for youngsters.

A card reader and teletype system is used to store and retrieve management data.

The system presently collects, analyzes, and feeds back to teachers and students individualized student's performance data, as well as analyzing the continuing growth that each youngster is making within math and reading. And, it creates and maintains student data files providing profile information for each teacher and statistical summaries.

In the near future, additions will be made to provide more automation in the testing functions of IPI, correlations of performance data of permanent record information and the beginning of a student guidance system.

The Richland Elementary School in Quakertown is an official RBS demonstration and development school and arrangements to visit the Richland School can be made by contacting the Principal.

Since October of 1967, Research for Better Schools, Inc. and the Division of Instructional Systems of the Philadelphia School District have been cooperating to adapt Individually Prescribed Instruction mathematics materials to Computer Assisted Instruction (CAI).

The basic function of the project is to convert IPI mathematics materials from booklet form to a format which permits their presentation to the student via a Computer Assisted Instruction system. This has involved two basic operations. First, the curriculum rewriting task; and second, a technical oriented encoding task to get the materials ready for the computer.

The CAI-IPI mathematics is presented to students at a specially designed computer terminal and has both keyboard and light pen response capabilities. Records of students' progress are stored in the computer and may be printed out upon request.

The program is presently in operation at the Intensive Learning Center at 5th and Luzerne Streets in Philadelphia. Arrangements may be made to visit the operation by contacting the Director of the Center.

The MITRE Corporation and Research for Better Schools, Inc. have submitted to the National Science Foundation and the U.S. Office of Education, a proposal that, if funded, will hasten the development and expansion of the CAI-IPI Program.

Research for Better Schools, Inc., as a subcontractor, will be responsible for the following portions of the program: curriculum development, dissemination, teacher and administrator training, and educational evaluation. It is anticipated that the current effort to computerize IPI mathematics by the Philadelphia School System will be enlarged and accelerated

for the Time-Shared Interactive Computer-Controlled Educational Television (TICCET) system, and voice assistance added.

The MITRE Corporation will have the responsibility for the following portions of the program: Overall program management, prime contractor responsibility, sub-contract management, hardware purchase and integration, software development, encoding the curriculum, operation and maintenance of the hardware and software, overall system evaluation, system simulation and optimization, site provision for early teacher acclimation to the hardware, and generation of technical specification for future competitive purchase of additional hardware systems.

Finally, it should be noted that Individually Prescribed Instruction, Automated Learning Management System, and Computer Assisted Instruction have been designed to take advantage of the best of our existing technology in order to individualize instruction for learners. The technology of IPI does indeed work -- the pace of adoption is still the unknown.

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